

ELECTRICAL CONNECTOR APPARATUS AND METHOD

Background of the Invention

5 The present invention relates to electrical connectors. In specific embodiments the invention pertains to an electrical connector for coupling to an insulated single conductor electrical cable or to a coaxial cable.

 Typically, in installing single conductor cable including a central conductor with an outer insulation, the end of the wire is stripped of insulation and the bare wire is inserted into
10 a connector where it is soldered, clamped or otherwise attached to the connector. Similarly, with coaxial cables which include a central conductor enclosed in an inner concentric insulation covered by a concentric conductive sheath and encased in an outer insulation, the common practice is to strip the outer insulation to expose the conductive sheath.

 It is an object of the present invention to provide an improved electrical connector
15 and method for mechanically coupling and for electrically coupling an insulated electrical cable to an electrical connector without the need for stripping the insulation from the cable.

Brief Summary of the Invention

 The subject invention pertains to an electrical connector having a housing with a
20 central bore for receiving an electrical cable, one or more clamping members having inwardly pointed ends in the bore and a closure member for insertion into the bore for closing the bore and for driving the pointed ends of the clamping members into mechanical connection with the electrical cable.

 In application to a single conductor cable, the pointed ends of the clamping members
25 may make mechanical connection to the cable and alternatively make electrical connection between the housing and the conductor of the cable. In application to a coaxial cable the pointed ends of the clamping members may make mechanical connection to the cable and electrical connection between the housing and the concentric sheath of the cable.

5 The closure member or end cap is moveable longitudinally into the bore of the housing and engages, at its outer periphery, the inner periphery of the bore. In its longitudinal movement into the bore it engages the ends of the clamping members to drive the ends radially into the electrical cable. The longitudinal movement of the end cap may be by way of threaded rotational movement or by the application of a longitudinally directed force.

10 The electrical connector of the invention may be provided with a center pin or prong for making an electrical connection beyond the connector, and may be provided with a mounting therefor, which extends the prong into the bore of the housing to make electrical contact with the central conductor of the cable. Alternatively, the housing may include a central guide and aperture which would permit the central conductor of a cable stripped of its insulation to extend appositely beyond the bore of the housing for making electrical connection beyond the connector.

15 Brief Description of the Drawings

Figure 1A shows an embodiment of the subject connector for use with a single conductor insulated electrical conductor.

Figure 1B shows a specific embodiment of an electrical connector in accordance with the subject invention for use with a coaxial cable type insulated electrical conductor.

20 **Figure 2** shows a specific embodiment of an electrical connector in accordance with the subject invention, incorporating an endcap having one or more protrusions.

Figure 3A shows an embodiment of the subject electrical connector, which incorporates a beveled ring and a compression ring.

25 **Figure 3B** shows the electrical connector of Figure 3A after insertion of the cap into the housing.

Figure 3C shows the electrical connector of Figure 3A incorporating a key and groove to prevent the beveled ring from rotating with respect to the housing.

Figure 4 shows an embodiment of the subject invention where clamping arms extend toward the end of the insulated electrical conductor.

Figure 5 shows an embodiment of the subject connector which utilizes the center conductor of the coaxial cable rather than a pin.

5 **Figure 6** shows an embodiment of the subject connector which utilizes the center conductor of the coaxial cable rather than a pin and the inner insulation of the coaxial cable to electrical isolate the center conductor of the coaxial cable from the housing.

10 **Figure 7** shows an end view of an electrically conductive clamp in accordance with the subject invention having eight clamping arms which have been manipulated into the clamped position.

Figure 8 shows a specific embodiment of an individual clamping arm broken away from the housing.

Figure 9A shows a side view of a conductive pin in accordance with the subject invention, incorporating a hollow portion having a single slit.

15 **Figure 9B** shows an end cross-sectional view of the hollow portion of the pin shown in Figure 9A.

Figure 10A shows a side view of a conductive pin in accordance with the subject invention, incorporating a hollow portion having two slits.

20 **Figure 10B** shows an end cross-sectional view of the hollow portion of the pin shown in Figure 10A.

Detailed Disclosure of the Invention

Referring to Figure 1, an electrical connector 100 in accordance with the subject invention is shown for use with a coaxial cable 11 having a single solid or braided conductor 12, a concentric insulation layer 13, a conductive sheath 14 and an outer insulation 15. Connector 100 has a housing 25 made up of a rotatable terminal section 25A, an interconnecting section 25B and a housing section 25C, which are in electrical contact with each other. Housing sections 25A, 25B, and 25C can be generally cylindrical in shape and designed such that section 25B holds section 25A in place and makes an interference fit with

section 25C. Section 25A can rotate relative to sections 25B and 25C about the axis of the connector, which allows section 25A to be threaded onto a counterpart connector. Alternatively, section 25A can be fixed such that all three sections 25A, 25B, and 25C form a single integral housing 25. In this case, the section 25A can slide onto counterpart connectors rather than being threaded.

Housing section 25C can have a central bore 105 with an open end 107. A conductive clamp 112 can be disposed within the bore. Conductive clamp 112 can be generally cylindrical in shape and include a collar portion 114 and one or more clamping arms 113 extending from collar portion 114. Preferably, the outer periphery of collar portion 114 is approximately the dimension of the inner periphery of bore 105. Collar portion 114 can support clamping arm(s) 113 in longitudinal extension toward open end 107 of bore 105. Clamping arm 113 can have a beveled edge 115 directed radially inward and which can be contacted to urge tip 133 radially inward. The clamping arm(s) 113 can make electrically conductive contact with the housing section 25C, for example, through collar 114. Alternatively clamping arm(s) 113 can be made integral with electrically conductive 25C and/or 25B.

The opposite end of the bore 105 can be closed by a plug 218 of electrical insulating material that can be secured in the interconnecting section 25B by a pressure fit or adhesive or other means, and has in it a central aperture 219 which communicates between the bore 105 and the open space of terminal section 25A. In the configuration of Figure 1, an electrically conductive pin 202 can be secured in the central aperture 219 with its head portion 202A projecting into bore 105 and its terminal portion 202B projecting into the open space of section 25A. The head portion 202A may be of a split pin type as illustrated but may also be of the solid pin type such as the terminal portion 202B as electrical connection conditions may dictate.

A closure member or end cap 200 of strong and resilient material such as plastic, nylon, rubber, brass or metal can be disposed in the open end 107 of the housing section 25C. Cap 200 is preferably of an internal diameter to receive a cable for connection, shown to be a coaxial cable 11 in Figure 1.

Figure 1 shows cap 200 positioned just inside housing 25 where protrusion 204 on cap 200 resides in indentation 206 of housing section 25C. The interaction of protrusion 204 and indentation 206 can hold cap 200 in position, allowing the connector to be held as a single unit prior to attachment to the end of a coaxial cable.

Accordingly, with the end of a coaxial conductor 11 inserted through cap 200 and into housing section 25, the cable can then be pushed further into housing 25 where the hollow pin 202 penetrates the end of the coaxial cable between the center conductor 12 of the cable and insulation layer 13, making electrical contact between the center conductor 12 and pin 202. Cap 200 can include a beveled edge 201 the end of the cap which enters open end 107 of the housing. Beveled edge 201 can be complimentary to beveled edge 115 of the clamping arm 3.

Once the electrical contact has been made between pin 202 and the center conductor of the coaxial cable, cap 200 can be pushed further into housing section 25C. Pushing cap 200 into housing section 25C can, by action of beveled edge 201 of cap 200 operating on beveled edge 115 of clamping arm(s) 113, push clamping arm(s) 113 toward the coaxial cable causing tips 133 of clamping arms 113 to penetrate and pass through outer insulation layer 15 of coaxial cable 11 and make electrical contact with outer conductor 14 of coaxial cable 11. As cap 200 is pushed further into housing section 25C, protrusion 204 interacts with indentation 208 and/or protrusion 210 interacts with indentation 206. The interaction of protrusion 210 and indentation 206 and/or protrusion 204 and indentation 208 can act to hold cap 200 securely in place inside housing 25. Alternatively, if desired, cap 200 can be separate from the housing and slipped onto the end of the coaxial cable prior to the end of coaxial cable being inserted into housing section 25C. Cap 200 can then be slid down the coaxial cable and pushed into housing section 25C.

Thus by cooperative action between the housing section 25, the end cap 200 and the clamping arm(s) 113, the cable 11 is securely attached mechanically to the connector 100 and in addition the clamping arm(s) 113 complete electrical contact between the outer conductor 14 of the cable and the housing 25 of the connector 100. Additionally, with respect to the embodiment shown in Figure 1, electrical contact is made with the center conductor 12 and

pin 202 of connector 100 which is electrically insulated from the electrical connection made between the conductor 14 and the housing 25 of connector 100.

Preferably, the subject connector is designed to resist the entry of moisture. For example, it is preferred to prevent moisture at the point of penetration of clamping arms 113 into the coaxial cable and at the end of the coaxial cable. Accordingly, O-ring seals 212, 214 and/or 216 can be utilized to reduce or prevent moisture at these sensitive areas.

Preferably, the tolerances of the inner diameter of housing section 25C, the thickness of cap 200, and the dimensions of the coaxial cable and its outer insulation are such that the penetration depth of the tip of the clamping arm 113 into the coaxial cable can be controlled. Such control of the penetration depth can be used to optimize the electrical contact between the clamping arms 113 and the housing, the impact the clamping arms have on the structure of the coaxial cable, and the friction created between the cap 200 and the coaxial cable.

Clamping arms 113 instead of being located in section 25C prior to the insertion of the end of the insulated conductor into section 25C, can be attached to the end of a coaxial cable prior to insertion of the end of the coaxial cable into housing section 25C. For example, a user can align collar 114 and clamping arms 113 on the end of a coaxial cable and then press the tips 133 of clamping arms 113 into the side of the coaxial cable by hand, with pliers, or with some other mechanism. The end of the coaxial cable can then be inserted into housing section 25C and cap 200 inserted into housing section 25C. In this embodiment, cap 200 need not necessarily press the clamping arms 113 into the coaxial cable, but preferably reaches far enough into housing section 25C to hold clamping arms in place with respect to the coaxial cable. In this case, the front of cap 200 need not have a beveled front edge.

In a further alternative embodiment, a tool might be used to push tips 133 of clamping arms 113 into the outer insulation of the coaxial cable prior to the insertion of cap 200 into housing section 25C. Such a tool can slide into housing 25C and urge clamping arms 113 into the side of the insulated electrical conductor. In this embodiment, the beveled edge of cap 200 can have a different shape, as the cap would not necessarily be responsible

for pushing the tips of clamping arm 113 into the coaxial. The cap 200 can still be useful for holding the clamping arms in position.

Figure 2 shows a variation of the connector 100 of Figure 1, wherein the conductive pin 202 is shown to have a head portion 202A which is of the solid pin type rather than a split pin type and wherein the cap 200 is modified to include one or more slots 221 in the side wall and an inner circumferential ridge 220 spaced intermediate the ends of the slot 221. The head portion 202A is illustrated as a solid pin type adapted for piercing either the stranded electrical conductor 21 of a single conductor cable 20 as shown or a stranded center conductor of a coaxial cable. Head portion 202A can also make electrical contact with a solid center conductor of a coaxial cable. The purpose of the slot 221 and ridge 220 is to provide a stress relief area around the circumference of the end cap 200. Accordingly, when the cable 20 is in place in the connector engaging the conductive pin 202 and the cap 200 has been pushed in to seat the conductive arms 113 in the outer wall 22 of the cable, further longitudinal pressure on the end of the cap causes the side wall of the cap 200 to move inwardly along the ridge 220 thereby applying clamping pressure to outer wall 22 of the cable 20 to further mechanically secure the cable in place in the connector. The use of the slotted end cap with a single conductor cable is merely illustrative and may be used advantageously with coaxial cables.

Figure 3A is an expanded view and Figure 3B is an assembled view of another embodiment of the invention of Figure 1 which includes a double beveled ring 222 and a compression fitting ring 224 to provide additional gripping action on a cable inserted in the connector. Beveled ring 222 is positioned in the housing section 25C such that a first beveled edge contact the beveled edge 115 of the clamping arms 113. Compression ring 224 can then be placed into housing section 25C such that compression ring 224 contacts the other edge of the beveled ring 222. When cap 200 is forced into housing section 25C it pushes compression ring 224 into beveled ring 222 which in turn forces clamping arms 113 radially inward to engage a cable inserted in the housing section. The ring 222 comes to rest and the compression ring 222, compressed between cap 200 and beveled ring 222 is forced radially inward against the coaxial cable to further grip the coaxial cable and hold it in place.

Figure 3C is a variation of the embodiment of Figures 3A and 3B in which the end cap 200 and the housing section 25C are threaded for rotational longitudinal movement instead of sliding longitudinal movement. In this embodiment the beveled ring 222A is keyed with a discrete protrusion 222B which fits into a longitudinal slot 226 in the housing 25C to prevent rotation of the ring against the surface 115 of the clamping arm(s) 113. In other respects the embodiment operates in the same manner as that of Figures 3A and 3B.

In the embodiment of Figure 4, the position of the conductive clamp 112 has been reversed from that shown in Figure 1 so that the clamping arms face inwardly in the bore 105. Further, the interior of the housing section 25C has been provided with a ramp 116 against which the beveled edge 115 of the clamping arm 113 rides. The interior end of the cap 200 has been made blunt in order to engage the conductive clamp 112. Accordingly, with a cable positioned in the connector, longitudinal movement of the cap 200 into the bore 105 forces the clamping arms 113 to ride up the ramp 116 and radially inward so that the tips 133 pierce into the cable.

Figure 5 shows an embodiment of the invention of Figure 1 wherein the center pin 202 has been removed and the cable 11 has been cut back to expose a length of the center conductor 12 adequate for projecting through the insulator plug 218 into the open portion of the terminal housing 25A. Further, Figure 5 shows an embodiment of the invention of Figure 1 wherein the center pin 202 and the insulator plug 218 have been removed and the cable 11 has been cut back to expose a length of the center conductor 12 adequate for projecting into the open portion of the terminal housing 25A and the insulation layer 15 and conductive sheath 14 have been cut back to expose the insulation layer 13 of sufficient length to nest in the interconnecting section 25B and to electrically isolate the conductor 12 from the housing 25. In all other respects the configuration of Figures 4 and 5 function in the same manner as described relative to that of Figure 1.

Figure 7 shows an end view of an embodiment having eight clamping arms 113 extending from a collar 114, as shown in Figure 1, which have been clamped into place. Clamping of arm 113 in order to drive tip 133 into the insulation can be accomplished, for example, with a special tool for reaching into housing 25C to urge arms 113 toward the

cable, by pushing cap 200 into housing 25C, or by pressing arms 113 into the insulation by hand, with pliers, or with another tool prior to insertion of the end of the insulated conductor into the housing. Dashed lines 226 and 228 represents the edges of the beveled surface 115 of the clamping arms. Around the outside collar 114 can be seen through the spacings between arms 113.

The curve of the end 133 can also be selected to optimize the performance of the connector. In Figure 7, the curve of end 133 is selected such that the eight ends form a circular pattern of deepest penetration into the conductive sheath of the coaxial cable. The dotted circle 232 in the center of Figure 6 represents the approximate location of the inner conductor of the coaxial cable. Referring to Figure 8, a single clamping arm 113 broken away from collar 114 is shown. The pointed end 133 of clamping arm 113 can have a variety of shapes, in order to optimize one or more operational characteristics of the electrical connector. In the embodiment shown in Figure 8, pointed end 133 is shaped such that as the clamping arms are manipulated to cause the piercing of the outer insulation, the sides 134 of the clamping arms come into contact with the adjacent clamping arms so as to prevent further penetration of the pointed end 133.

Referring to Figures 9A, 9B, 10A, and 10B, specific embodiments of a pin 202 which can be utilized with respect to the electrical connectors of the subject invention is shown. For example, either pin shown in Figures 9A and 10A, or variations thereof, can be incorporated with the electrical connectors shown in Figures 1-6. Both Figures 9A and 10A show side views of pins having a hollow portion on one end for receiving an electrical conductor and a solid portion for connecting with and an external apparatus on the other end. Other pin embodiments are possible which, for example, have a solid portion at each end of the pin or have a hollow portion at each end of the pin. In addition, the entire pin can be hollow if desired. Preferably, the hollow portion of each pin can have one or more slits. The number, lengths, and widths, of the slits can vary depending on the application. Figure 9A shows a slit which extends about half the length of the hollow portion of the pin, while Figure 10A shows two slits which extend essentially the entire length of the hollow portion of the pin. Figures 9B and 10B show end views of the hollow portions of the pins shown in

Figures 9A and 10A, respectively. These slits can allow the hollow portion to expand to just the right size to receive an electrical conductor such that a good electrical contact can be made.

5 The present invention should not be construed as limited to the forms shown which are to be considered illustrative rather than restrictive.